

Rec'd PCT/PTO 22 MAR 2005

528731

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

10/528731

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
8 April 2004 (08.04.2004)

PCT

(10) International Publication Number
WO 2004/029742 A1

- (51) International Patent Classification⁷: G05B 23/02 (74) Agent: SIEMENS AKTIENGESELLSCHAFT; Post-box 22 16 34, 80506 München (DE).
- (21) International Application Number: PCT/EP2002/012457 (81) Designated States (*national*): AU, CN, IN, JP, MX, RU, US, ZA.
- (22) International Filing Date: 7 November 2002 (07.11.2002) (84) Designated States (*regional*): European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR).
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data: 02021499.5 26 September 2002 (26.09.2002) EP
- (71) Applicant (*for all designated States except US*): SIEMENS AKTIENGESELLSCHAFT [DE/DE]; Wittelsbacherplatz 2, 80333 München (DE).
- (72) Inventors; and
- (75) Inventors/Applicants (*for US only*): FICK, Wolfgang [DE/DE]; Schäfflarnstr. 130, 81371 München (DE). APPEL, Mirko [DE/DE]; Pfälzer-Wald-Str. 47, 81539 München (DE). GERK, Uwe [DE/DE]; Abtsdorf 64, 96158 Frensdorf (DE).
- Declarations under Rule 4.17:**
- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations AU, CN, IN, JP, MX, RU, ZA, European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR)
- of inventorship (Rule 4.17(iv)) for US only
- Published:**
- with international search report
- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

(54) Title: METHOD AND APPARATUS FOR MONITORING A TECHNICAL INSTALLATION, ESPECIALLY FOR CARRYING OUT DIAGNOSIS

(57) Abstract: The invention makes use of human perception to derive potential faults of at least one component of the technical installation. A sensor device may be employed for acquiring at least one human physiological reaction whereby said human physiological reaction may include at least one of neuritic currents and changes in neuritic currents and blood pressure and changes in blood pressure and pulse rate and changes in pulse rate and pulse strength and changes in pulse strength and galvanic skin reflex and changes in galvanic skin reflex and breathing patterns.

BEST AVAILABLE COPY

WO 2004/029742 A1

Description

Method and Apparatus for monitoring a technical installation, especially for carrying out diagnosis

5

The invention relates to a method respectively apparatus for monitoring a technical installation.

10

Another object of the present invention is to provide a qualitative and/or quantitative assessment respectively diagnosis of a technical installation, especially of a power plant including turbines and/or generators.

15

Known methods of monitoring a plant include maintenance personnel walking around the plant for assessment purposes based on human observations.

20

Experienced maintenance staff may detect deviations from normal operating conditions such as unusually loud pumps and drives or unusual vibrations of a plant component and report those observations.

25

But usually those observations are not stored for future reference and therefore no long term trend analysis can be applied.

30

Furthermore slight deviations cannot be tracked and changes in maintenance staff may lead to conclusion failures since observations of different persons are usually not compared to each other or transferred towards a "neutral" observation, or are simply not comparable and/or transferable.

35

It is therefore an object of the present invention to provide an advanced method respectively apparatus for monitoring a technical installation including human observations.

This and other objects are solved by a method respectively apparatus as laid down in the independent claims. Preferred

embodiments are subject to the corresponding dependent claims.

The invention includes utilizing human skills and psychology.

5

For example, the galvanic skin reflex or other physiological reactions can be used to determine the state of a maintenance worker when observing a plant component.

10

Even if he is not aware of a potential failure of a plant component, even slight deviations from a former operating situation of said component may nevertheless be sensed by him unwillingly and cause a physiological reaction such as a change in blood pressure, pulse rate, galvanic skin reflex, breathing pattern, cardiovascular activity etc. without being

15

aware that a failure might be in progress.

20

An instrument such as a polygraph ("lie detector") and its related sensors can advantageously be used to acquire and store at least part of a.m. human physiological reactions during an inspection tour around the plant.

25

To avoid wrong conclusions based on acquired and/or stored human physiological reactions, the person performing the inspection tour should be "calibrated" before performing the inspection tour, because there are factors effecting e.g. the heartbeat such as emotion, exercise, hormones, temperature, pain and stress. Furthermore the normal number of pulse beats per minute in the average adult varies from 60 to 80, with fluctuation occurring with exercise, injury, illness, and emotional reactions. So, in a preferred embodiment of the invention, the "normal state" of said person is acquired and stored before said inspection tour as a reference basis.

30

The acquisition of human physiological reactions may include voluntary and/or involuntary reactions of the nervous system.

35

The somatic nervous system is also the voluntary nervous system because its motor functions may be consciously controlled. It includes somatic motor nerve cells, which carry impulses from the CNS to the skeletal muscles. The impulses carried by the somatic motor nerves produce contractions of the skeletal muscles. Muscle contractions that are brought about by the somatic nervous system may be reflex responses; those may not be consciously controlled.

10 The autonomic nervous system - or involuntary nervous system - in contrast to the somatic nervous system, is composed of visceral motor nerve cells, which transmit impulses to smooth muscles, cardiac muscle, and glands. Visceral motor impulses generally cannot be consciously controlled.

15

The autonomic nervous system may be subdivided functionally into sympathetic and parasympathetic divisions which are actually overlapping divisions.

20 Generally the parasympathetic nervous system is responsible for regulating the body during periods of low stress, uneventful times, times of calm and relaxation.

While the parasympathetic nervous system decreases heart rate and promotes digestive functions, the sympathetic nervous system takes charge during times of high stress. The sympathetic nervous system increases heart, and breathing rates. It helps us respond when we are called upon to perform a physical feat such as running to get away from something threatening us or standing and confronting a threat to our welfare, or well being. Many times people refer to this reaction as "fight or flight".

Physiological changes caused by any of the a.m. nervous systems can be monitored by physiological recording devices such as a polygraph, an instrument equipped with sensors, which, when attached to the body, can pick up subtle physiological changes.

These fluctuations, in the form of electrical impulses, are amplified within the polygraph and may activate pens that then record the changes on a continuously moving roll of paper.

5

When sensors are attached to the scalp, the result is an EEG, electroencephalogram. When the sensor measures changes in the electrical resistance to the skin, the result is a reading of galvanic skin response (GSR).

10

When the sensor is used to pick up subtle changes in the electrical activity of muscles, the result is an electromyogram (EMG).

15

A polygraph can also measure a number of other physiological responses such as heart rate and blood pressure and produce recordings of physiological phenomena such as breathing, galvanic skin resistance and cardio tracing that may be used as the basis for the application of a reliable technique for diagnosing the operational state of a plant component

20

A standard polygraph can be used for recording changes in blood pressure, pulse rate, pulse strength, galvanic skin reflex (sweat gland activity), and upper and lower breathing patterns. It does not matter if the subject is "nervous" during the testing process. The polygraph records significant changes from the subject's "normal state".

25

Furthermore, a polygraph is suitable for recording changes in a person's Sympathetic Nervous System, part of the Autonomic Nervous System, which operates independently of conscious thought.

30

For example, the lungs and heart continue to operate even when you are asleep - you don't have to think about it.

35

These systems can be consciously controlled only very slightly.

Summing up the invention, it is stated that it utilises human perception, similar to a polygraph (lie detector).

- 5 Maintenance staff performing inspection tours may be equipped with a head-mounted (e.g. digital) camera to record their sight and changes in direction of sight.

- 10 Simultaneously, neuritic currents, changes in blood pressure, pulse rate, pulse strength, galvanic skin reflex (e.g. sweat gland activity) upper and lower breathing patterns etc. may be recorded.

- 15 Thus the five human senses can be employed. Notes can be added manually (e.g. via PDA, hand held PC etc.).

The results can be stored, e.g. in a database, and be used for trending and plant assessment purposes.

- 20 The analysis of human perception and sight reveals the condition of any particular plant equipment / plant component, e.g. pumps, engines, turbines, generators and so on.

Example:

- 25 No unusual observations were made, e.g. by plant walkers / plant workers for months.

- 30 However, one day a belt drive between an electric motor and a pump is louder than usual. The reason for this may be that one of three belts is slightly loose. After a brief check, the worker realises that there is no urgent need to tighten or change the belt.

- 35 However, on subsequent tours, the workers' perception concerning the belt drive will yield the condition of the belt drive, e.g. how long is the belt drive observed on subsequent

tours, level of change in human perception while observing the belt drive, and so on.

5 In general, the five human senses may be efficiently utilised for plant assessment.

Human senses are very sensitive and can not yet be reproduced and/or simulated i.e. by a computer and appropriate software.

10 However, objective assessment from human observation is usually hard to obtain; to overcome that problem the invention neatly combines human sensing with objective recording to a powerful plant assessment tool.

Claims

- 5 1. Method for monitoring a technical installation, especially
for carrying out diagnosis,
comprising acquiring at least one human physiological re-
action of a human during an inspection tour of said human
around at least one part of the technical installation.
- 10 2. Method according to claim 1,
whereby said human physiological reaction includes at
least one of neuritic currents and changes in neuritic
currents and blood pressure and changes in blood pressure
15 and pulse rate and changes in pulse rate and pulse
strength and changes in pulse strength and galvanic skin
reflex and changes in galvanic skin reflex and breathing
patterns.
- 20 3. Method according to claim 1 or 2,
whereby a camera device is employed to record said human's
sight including changes in said human's directions of
sight.
- 25 4. Method according to any of claims 1 to 3,
whereby said human is equipped with at least one sensor
device to acquire said human's physiological reaction.
- 30 5. Method according to any of claims 1 to 4,
further comprising storing said human's physiological re-
action in a database, said database representing a history
of said human's physiological reaction.
- 35 6. Method according to any of claims 1 to 5,
further comprising assigning said acquired human physio-
logical reaction at least one of a failure and process

disturbance and normal operation of at least one component of the technical installation.

7. Apparatus for carrying out diagnosis of a technical installation,

comprising at least one sensor device for acquiring at least one human physiological reaction of a human during an inspection tour of said human around at least one part of the technical installation.

8. Apparatus according to claim 7,

whereby said human physiological reaction includes at least one of neuritic currents and changes in neuritic currents and blood pressure and changes in blood pressure and pulse rate and changes in pulse rate and pulse strength and changes in pulse strength and galvanic skin reflex and changes in galvanic skin reflex and breathing patterns.

9. Apparatus according to claim 7 or 8,

further comprising a camera device to record said human's sight including changes of said human's directions of sight.

10. Apparatus according to any of claims 7 to 9,

further comprising a database for storing said human physiological reaction, said database representing a history of said human's physiological reaction.

11. Apparatus according to any of claims 7 to 10,

whereby said acquired human physiological reaction is assigned at least one of a failure and process disturbance and normal operation of at least one component of the technical installation.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 02/12457

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G05B23/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 93 21615 A (PROMOTIONS SA ;RINDEGAARD BO (PA)) 28 October 1993 (1993-10-28) page 1, line 6 -page 3, last line; figures 1,2	1-5,7-10
X	US 6 091 334 A (GALIANA HENRIETTA L ET AL) 18 July 2000 (2000-07-18) column 1, line 26 - line 41; claims 1-5	1-5,7-10
X	US 5 867 587 A (RAMROTH RICHARD ROY ET AL) 2 February 1999 (1999-02-02) column 1, line 9 -column 2, line 39 column 14, line 37 - line 42	1-5,7-10

	--- -/-	

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the... invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone.

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

G document member of the same patent family

Date of the actual completion of the international search

13 March 2003

Date of mailing of the international search report

28/03/2003

Name and mailing address of the ISA
European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Helot, H

INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 02/12457

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 104 948 A (POPE ALAN T ET AL) 15 August 2000 (2000-08-15) abstract column 1, line 21 -column 3, line 64; figures 1,2 -----	1-5,7-10

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 02/12457

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 9321615	A	28-10-1993	SE 506716 C2 DE 69320801 D1 DE 69320801 T2 EP 0638193 A1 SE 9201255 A WO 9321615 A1	02-02-1998 08-10-1998 29-04-1999 15-02-1995 22-10-1993 28-10-1993
US 6091334	A	18-07-2000	NONE	
US 5867587	A	02-02-1999	NONE	
US 6104948	A	15-08-2000	NONE	

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☒ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☐ **FADED TEXT OR DRAWING**
- ☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☐ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.